

A new species of *Simulium* (*Nevermannia*) from Izu Islands, Japan (Diptera: Simuliidae)

Hiroyuki TAKAOKA¹⁾ and Katsumi SAITO²⁾

¹⁾ Department of Infectious Disease Control, Faculty of Medicine, Oita University,
Hasama, Yufu City, Oita, 879–5593 Japan

²⁾ Laboratory of Medical Zoology, College of Environmental Health, Azabu University,
1–17–71, Fuchinobe, Sagamihara, Kanagawa, 229–8501 Japan

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Abstract: A new species of the black fly, *Simulium* (*Nevermannia*) *izuense* sp. nov., is described on the basis of samples collected from the Izu Islands, Tokyo, Japan. This new species is assigned to the *feuerborni* species-group of the subgenus *Simulium* (*Nevermannia*), and is very similar to *S. (N.) sasai* (Rubtsov), but is easily distinguished from the latter species by the pupal gill with a short stalk of the ventral paired filaments, the simple cocoon without any anterodorsal projection, and the short thumb-like secondary lobules of the larval rectal organ.

Key words: *Simulium*, black fly, Simuliidae, Japan, new species, *Nevermannia*

In Japan, the *feuerborni* species-group within the subgenus *Simulium* (*Nevermannia*) Enderlein, redefined by Takaoka (2003), is represented by four species, *S. (N.) mie* Ogata and Sasa, *S. (N.) morisonoi* Takaoka, *S. (N.) saitoi* Takaoka, and *S. (N.) sasai* (Rubtsov) (Crosskey and Howard, 1997; Takaoka and Saito, 2000). We collected one more species of the *feuerborni* species-group from the Izu Islands, Tokyo, which is similar to *S. (N.) sasai* but is easily distinguished from the latter species by its simple cocoon. This is here described as a new species.

The terms for morphological features used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Oita University, Oita, Japan.

Simulium (*Nevermannia*) *izuense* sp. nov.

DESCRIPTION. Female. Body length 3.5–3.7 mm. **Head.** Narrower than thorax. Frons brownish-black, slightly shiny at certain angle

of light, thinly whitish-grey pruinose, densely covered with whitish-yellow recumbent hairs interspersed with several dark longer and stouter hairs along each lateral margin. Frontal ratio 1.49–1.67 : 1.00 : 1.91–1.96. Frons-head ratio 1.0 : 4.3–4.5. Fronto-ocular area (Fig. 1A) well developed, triangular, directed somewhat upward. Clypeus brownish-black, whitish-grey pruinose, densely covered with whitish-yellow recumbent hairs (except portion near upper margin bare) intermixed with several dark longer and stouter hairs on each side. Labrum about 1.1 times as long as clypeus. Antenna composed of 2+9 segments, medium brown, except scape, pedicel, and base of 1st flagellar segment ochreous; 1st flagellar segment about 1.8 times as long as 2nd one. Maxillary palp consisting of 5 segments, medium to dark brown, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 0.81–0.87 : 1.61–1.66; 3rd segment (Fig. 1B) much enlarged, with sensory vesicle elongate, 0.51 times as long as 3rd segment, with medium-sized or large opening. Maxillary lacinia with 8–10 inner teeth and 12–15 outer ones. Mandible with 21 inner teeth and lacking outer teeth. Cibarium smooth on posterior margin, with well sclerotized arms directed anterolaterally. **Thorax.** Scutum

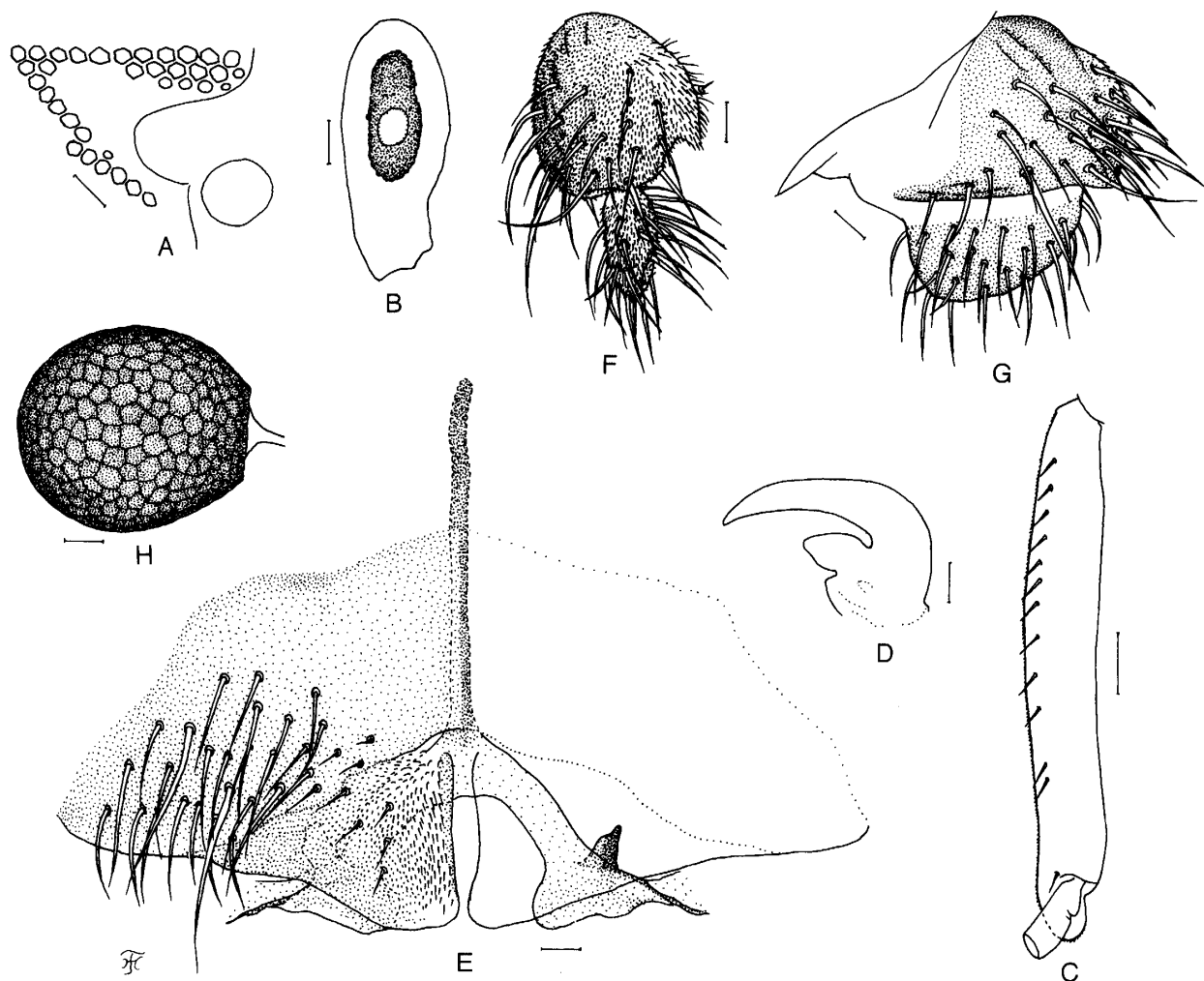


Fig. 1. Female of *Simulium* (*Nevermannia*) *izuense* sp. nov. A, fronto-ocular area (right side); B, 3rd segment of maxillary palp with sensory vesicle (right side, front view); C, basitarsus and second tarsal segment of hind leg showing calcipala and pedisulcus (left side, outer view); D, claw; E, 8th sternite, ovipositor valves and genital fork *in situ* (ventral view); F and G, paraprocts and cerci (right side; F, ventral view; G, outer view); H, spermatheca. Scale bars. 0.1 mm for C; 0.04 mm for A and B; 0.02 mm for E-H; 0.01 mm for D.

medium brown (except anterolateral calli ocherous) though much darker near lateral margins and on prescutellar area, shiny at certain angle of light, thinly whitish-grey pruinose, with 3 faint dark narrow longitudinal vittae (1 medial and 2 submedial), densely covered with whitish-yellow recumbent hairs, and with several dark brown upright hairs on prescutellar area. Scutellum ocherous, with many dark upright hairs as well as whitish-yellow shorter hairs. Postnotum dark brown, thinly whitish-grey pruinose, shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum longer than deep, dark brown, and bare. **Legs.** Foreleg: coxa whitish-yellow; trochanter light brown; femur medium brown with apical cap dark brown; tibia dark brown

with apical cap brownish-black; tarsus brownish-black; basitarsus slightly dilated, 7.2 times as long as its greatest width. Midleg: coxa medium brown with posterior surface brownish-black; trochanter yellow; femur yellow to ocherous, with apical cap medium brown; tibia light to medium brown with apical cap dark brown and extreme base yellow; tarsus dark brown to brownish-black. Hind leg: coxa light to medium brown; trochanter yellow; femur yellow to ocherous with apical cap dark brown; tibia light brown on basal 2/3 except base pale ocherous and subbasal small portion medium brown, and dark brown on apical 1/3; tarsus dark brown except a little more than basal 1/2 of basitarsus and basal 1/2 of 2nd segment light to medium brown;

basitarsus (Fig. 1C) nearly parallel-sided, 6.6 times as long as wide, and 0.69 times and 0.59 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 1C) well developed, nearly as long as wide, and 0.63 times as wide as greatest width of basitarsus; pedisulcus (Fig. 1C) well developed. Claws (Fig. 1D) each with large basal tooth 0.45 times as long as claw. **Wing.** Length 2.9 mm. Costa with 2 parallel rows of dark short spines as well as dark hairs except subbasal portion of costa near humeral cross vein with patch of whitish hairs. Subcosta with dark hairs except apical 1/4 to 1/3 bare. Basal portion of radius fully haired; R_1 with dark spinules and hairs; R_2 with dark hairs. Hair tuft on stem vein dark brown. Basal cell absent. **Abdomen.** Basal scale light brown, with fringe of pale long hairs. Dorsal surface of abdomen medium brown except that of segment 2 ochreous though tergal plate light brown, moderately covered with whitish-yellow short hairs interspersed with dark ones; tergite 5 slightly shiny at certain angle of light, tergites 6–9 shiny when illuminated; ventral surfaces of abdominal segments 2–7 pale ochreous except large medial sternal plate of segment 7 medium brown. **Genitalia.** Sternite 8 (Fig. 1E) wide, bare medially but furnished with 26–32 medium-long and long hairs as well as a few short hairs on each side. Ovipositor valves (Fig. 1E) triangular, thin, membranous except inner margin narrowly sclerotized, densely covered with microsetae interspersed with 5–9 short hairs except posteromedial corner bare; inner margins gently sinuous and narrowly separated medially from each other. Genital fork (Fig. 1E) of inverted Y-form, with well sclerotized stem and wide arms; each arm with wide round lobe-like projection directed medioposteriorly and prominent projection directed forward. Paraproct (Fig. 1F,G) of usual form, only slightly protruding ventrally, with 22–24 hairs on ventral and lateral surfaces, and with 11 or 12 sensilla on anteroinner surface. Cercus in lateral view (Fig. 1G) rounded posteriorly, 0.57 times as long as paraproct. Spermatheca (Fig. 1H) ovoidal, about 1.2 times as long as its greatest width, strongly sclerotized except small area around juncture to duct, and duct itself unsclerotized, with distinct reticulate surface pattern, and without internal setae; main spermathecal duct narrow, while both accessory ducts slightly

wider than main duct.

Male. Body length 2.6–3.2 mm. **Head.** As wide as or slightly narrower than thorax. Holoptic; upper eye consisting of large facets in 21 or 22 vertical columns and 23 horizontal rows. Clypeus dark brown, not shiny, whitish-grey pruinose, moderately covered with yellow short and long hairs interspersed with dark long hairs except medial portion narrowly bare longitudinally. Antenna composed of 2+9 segments, medium brown except base of 1st flagellar segment yellow; 1st flagellar segment elongate, 1.9–2.2 times as long as 2nd one. Maxillary palp medium to dark brown, composed of 5 segments, proportional lengths of 3rd, 4th, and 5th segments 1.00:0.92–0.94:1.94–1.96; 3rd segment (Fig. 2A) of moderate size; sensory vesicle (Fig. 2A) small, globular or ellipsoidal, 0.16 times as long as 3rd segment, with very small opening. **Thorax.** Scutum dark brown (except anterolateral calli medium brown), shiny at certain angle of light, densely covered with golden-yellow recumbent hairs, and with several dark brown upright hairs on pre-scutellar area; 3 dark narrow longitudinal vittae (1 medial and 2 submedial) invisible or barely visible. Scutellum light brown, with many dark upright hairs as well as golden-yellow shorter hairs. Postnotum dark brown, thinly whitish-grey pruinose, shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum longer than deep, dark brown, and bare. **Legs.** Foreleg: coxa dark yellow; trochanter medium brown except base dark yellow though most of inner surface dark yellow; femur medium brown with apical cap dark brown though most of inner surface dark yellow or ochreous; tibia and tarsus brownish-black; basitarsus very slightly dilated, 7.6 times as long as its greatest width. Midleg: coxa medium brown with posterior surface dark brown; trochanter light brown except base dark yellow; femur light brown with apical cap dark brown; tibia dark brown to brownish-black; tarsus brownish-black. Hind leg: coxa light brown; trochanter yellow; femur light brown with apical cap dark brown; tibia dark brown to brownish-black with extreme base yellow; tarsus medium to dark brown; basitarsus (Fig. 2B) enlarged, spindle-shaped, 4.7 times as long as its greatest width, and 0.88 times and 0.85 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 2B) well developed, slightly shorter than

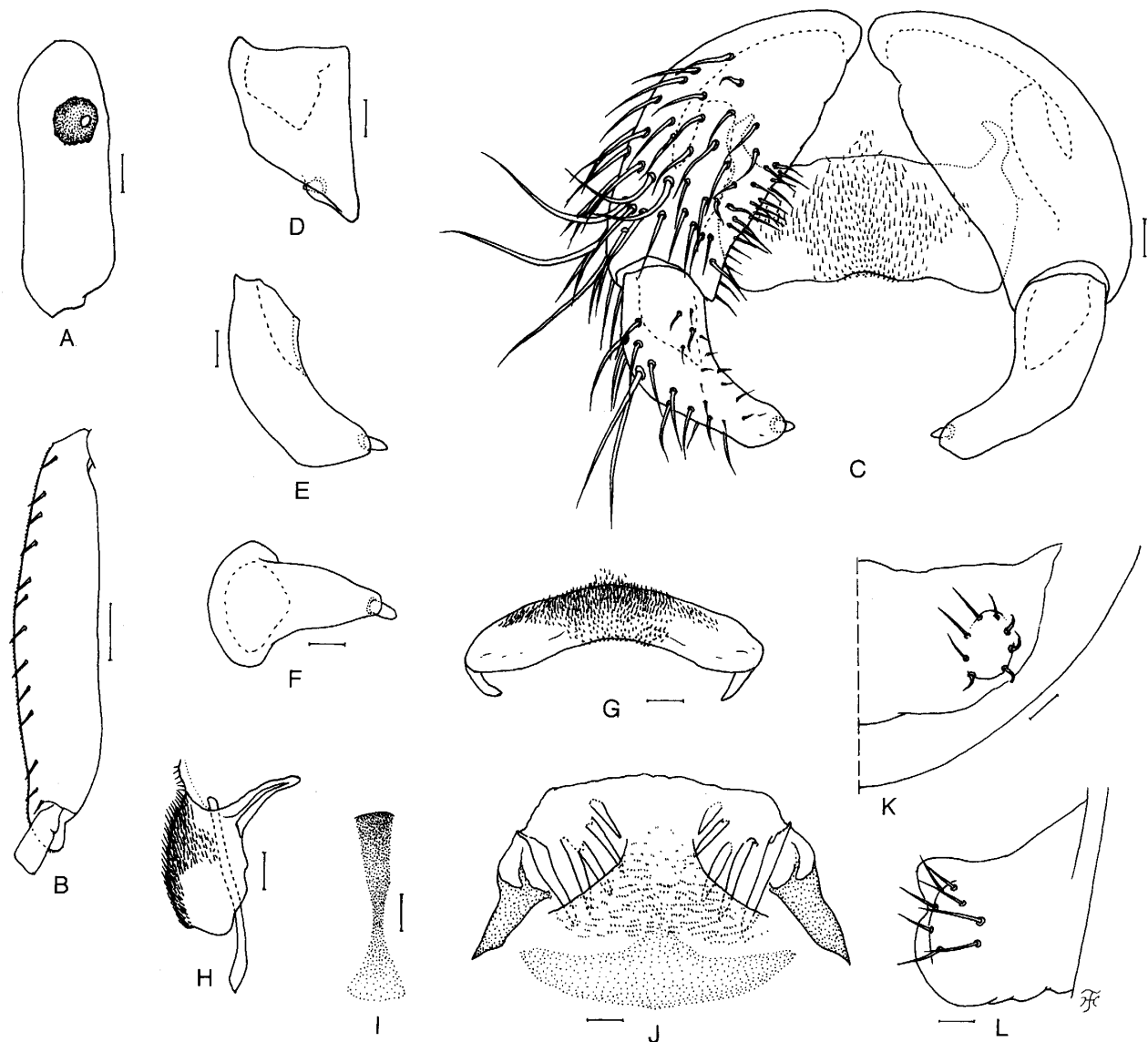


Fig. 2. Male of *Simulium (Nevermannia) izuense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side, front view); B, hind basitarsus (left side, outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D-F, styles (right side; D, ventrolateral view; E, medial view; F, end view); G, ventral plate (end view); H, ventral plate and median sclerite (lateral view); I, median sclerite; J, parameres, aedeagal membrane and dorsal plate *in situ* (posterodorsal view); K and L, 10th abdominal segments with cercus (left side; K, end view; L, outer view). Scale bars. 0.1 mm for B; 0.02 mm for A and C-L.

its width at base, and 0.45 times as wide as greatest width of basitarsus; pedisulcus (Fig. 2B) weakly developed. **Wing.** As in female except subbasal patch of white hairs on costa indistinct and subcosta with 3–10 hairs; length 2.5–2.6 mm. **Abdomen.** Basal scale brownish-black, with fringe of yellow long hairs. Dorsal surfaces of abdominal segments dark brown, not shiny, covered with yellow and dark simple hairs; lateral and ventral surfaces of abdominal segments 2–4 dull yellow though sternites of segments 3 and 4 light to medium brown; ven-

tral surfaces of segments 5–8 light to medium brown. **Genitalia.** Coxite in ventral view (Fig. 2C) subquadrate, much longer than wide. Style in ventral view (Fig. 2C) short, 0.7 times as long as coxite, bent inwardly, narrowed apically, with stout apical spine; style in ventrolateral view (Fig. 2D) broad, slightly narrowed from base to a little beyond middle, then abruptly tapered apically; style in medial view (Fig. 2E) gently curved inwardly and nearly parallel-sided; style in end view (Fig. 2F) tapered inwards. Ventral plate in ventral view (Fig. 2C)

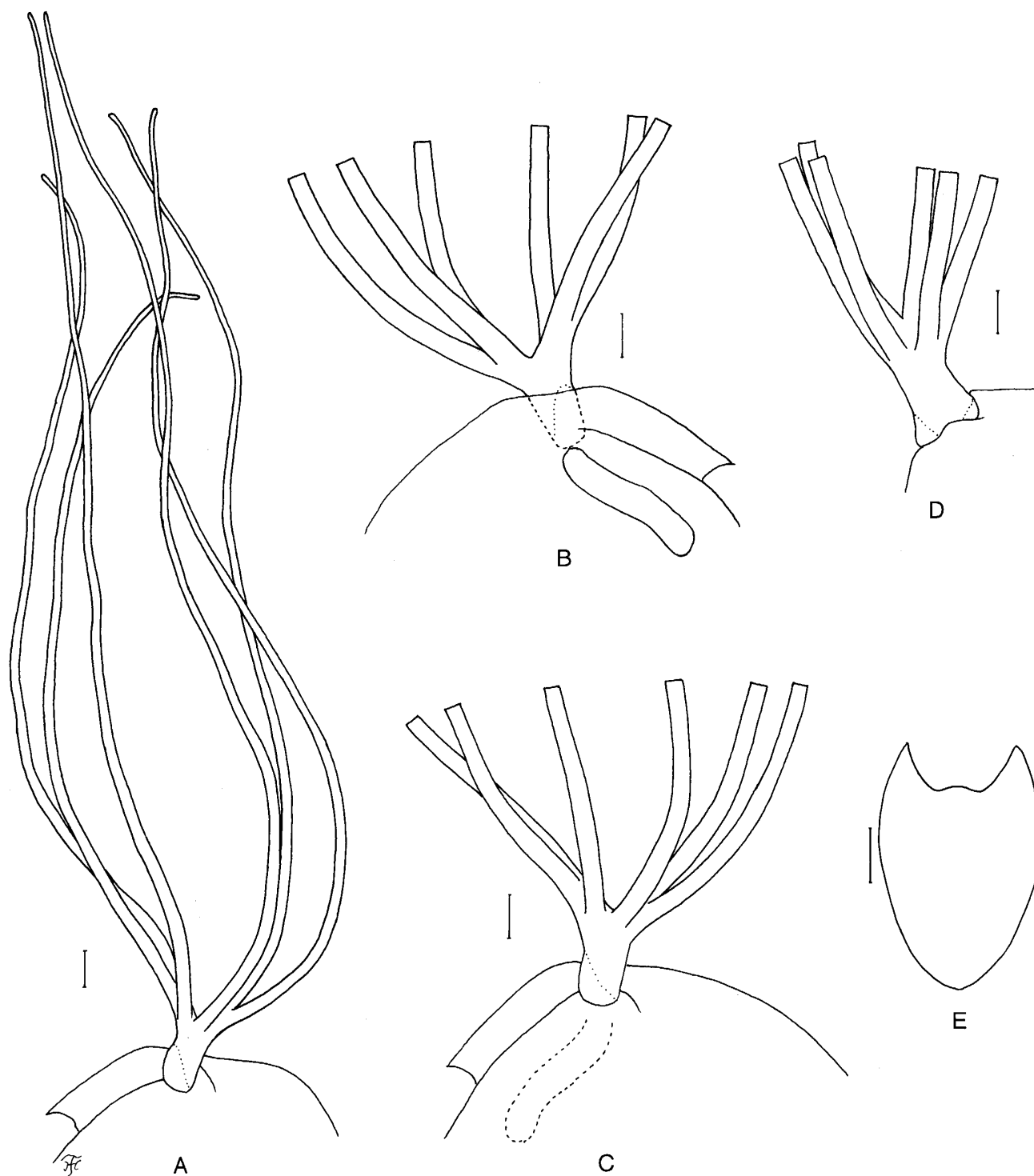


Fig. 3. Pupa of *Simulium* (*Nevermannia*) *izuense* sp. nov. A, gill filaments (left side, outer view); B–D, basal portions of gill filaments (all left side; B, inner view; C, outer view; D, dorsal view); E, cocoon (dorsal view). Scale bars. 1.0 mm for E; 0.1 mm for A–D.

lamellate, much shorter than wide, well sclerotized, with 3 concavities on posterior margin, and moderately covered with fine short setae on ventral surface except lateral portions bare; arm of moderate length, slender, directed anteriorly and curved inwardly; ventral plate in

end view (Fig. 2G) with fine short setae centrally on posterior surface; ventral plate in lateral view (Fig. 2H) rounded ventrally with slender long arm directed anterodorsally. Median sclerite (Fig. 2I) simple, club-shaped, narrow, somewhat widened toward apex. Parameres

(Fig. 2J) with 5 or 6 hooks of different sizes. Aedeagal membrane (Fig. 2J) moderately covered with spinous microsetae, moderately sclerotized basally forming dorsal plate (Fig. 2J). Ventral surface of 10th segment without any hairs near each posterolateral corner. Cercus (Fig. 2K, L) small, rounded and encircled by 8–10 simple hairs.

Pupa. Body length 3.5–4.4 mm. **Head.** Integument dark yellow to light brown, moderately covered with round tubercles; antennal sheaths bare; frons with 2 short slender simple trichomes on each side; face with 1 medium-long simple trichome (1.6 times as long as the longer frontal trichome) on each side. **Thorax.** Integument dark yellow to light brown, moderately covered with round tubercles, with 3 very long slender simple trichomes with coiled apex mediodorsally, 2 slender simple trichomes (1 very long and 1 short) mediolaterally, 1 medium-long slender simple trichome posterolaterally, and 3 short slender simple trichomes ventrolaterally, on each side. Gill (Fig. 3A–D) with 6 long thread-like slender filaments arranged in groups of 2+1+1+2 filaments from dorsal to ventral, all arising from short common basal stalk; dorsal pair of filaments with short stalk, directed slightly upwards and forwards, then downwards, ventral pair of filaments also with short stalk, directed downward and forwards, and middle 2 filaments arising somewhat separated from each other, or close together but not sharing stalk, and 1 of 2 filaments directed forwards and downwards, another filament directed downwards and forwards; all filaments dark brown, tapered apically, subequal in length to one another (lengths from base of gill to tips of filaments variable from 2.8 to 3.7 mm depending upon individual pupae), and shorter than pupal body; cuticular surface with distinct annular ridges and furrows (though ridges becoming indistinct apically and also near base), and densely covered with minute tubercles of different sizes (larger ones on ridges and smaller ones on interruges). **Abdomen.** Dorsal surfaces of all segments moderately sclerotized, light to medium brown, densely and elaborately covered with minute tubercles; segment 1 with 1 short slender simple seta on each side; segment 2 with 1 short slender simple seta and 5 very short spinous setae on each side; segments 3 and 4 each with 4 hooks and 1 very short spinous seta on each side; segments 5–9 each with spine-combs

directed backward in transverse row on each side; segments 6–9 each with comb-like groups of minute spines on each side; segment 9 with a pair of distinct cone-shaped terminal hooks curved posteroinwardly. Lateral surfaces of segments 2–4 each with 3 spinous setae on each side. Ventrally, segments 3–8 with comb-like groups of minute spines; segments 5–8 each with a pair of weakly-sclerotized light yellowish wide submedial sternal plates, on which comb-like groups of minute spines present; segment 4 nearly transparent, with 2 short simple hooklets and 2 short simple slender setae on each side; segment 5 with a pair of bifid hooks submedially and a few short slender setae on each side; segments 6 and 7 each with 1 bifid hook submedially and 1 simple hook laterally, and a few slender setae on each side. **Cocoon** (Fig. 3E). Simple, wall-pocket-shaped, compactly woven without open spaces in web, thin, with anterior margin thickly woven often forming short bulge, and extending ventrolaterally; individual threads visible; 4.0–4.8 mm long by 2.5–3.3 mm wide.

Mature larva. Body length 7.0–9.0 mm. Body greyish, with well-defined colored markings (Fig. 4A); i.e., abdominal segments 3 and 4 each with 3 reddish-brown spots on each side, of which 2 spots lying submedially on dorsal surface though posterior spot usually faint if any and often disappeared and 1 lying medially on lateral surface; abdominal segment 5 on each side with 1 reddish-brown spot submedially on anterior 1/2 of dorsal surface and 1 transverse similar colored band along its posterior margin; and abdominal segment 6 on each side with 1 transverse reddish-brown broad band gradually becoming faint laterally along anterior margin on anterior 1/2 of dorsal surface though this transverse colored band often replaced by small submedial spot. Cephalic apotome whitish-yellow to dark yellow except posterior margin darkened, with distinct positive head spots; lateral surface of head capsule dark yellow, with dark brown eyebrow containing dark spot; 2 large spots behind eye-spot region and 3 isolated spots below eye-spot region distinctively positive; ventral surface of head capsule (Fig. 4B) dark yellow to light brown except postgenal bridge mostly medium to dark brown, and basal area on each side of postgenal cleft dark brown; horizontal and round spots on each side of postgenal cleft distinctively positive. Cervical

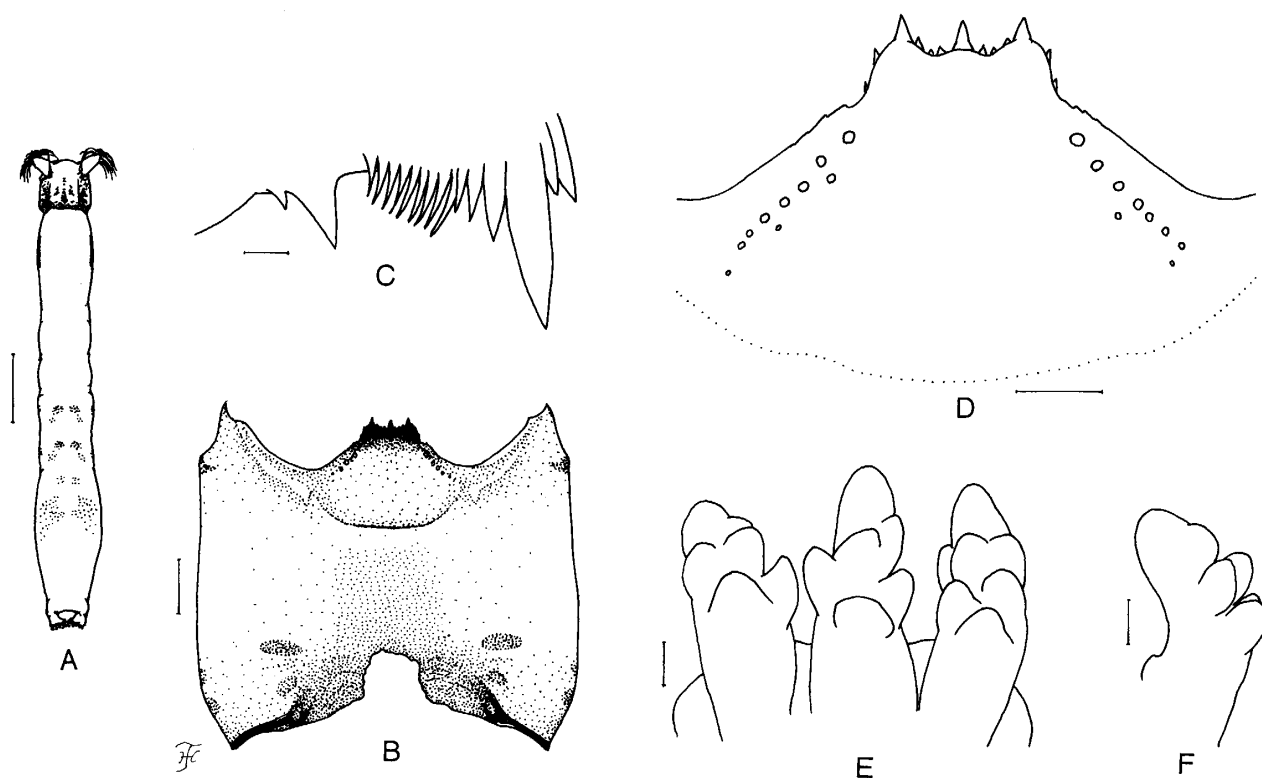


Fig. 4. Mature larva of *Simulium* (*Nevermannia*) *izuense* sp. nov. A, whole body (dorsal view); B, head capsule (ventral view); C, mandible; D, hypostomium; E and F, rectal organ (E, dorsal view; F, lateral view of left lobe). Scale bars. 1.0 mm for A; 0.1 mm for B; 0.05 mm for D–F; 0.01 mm for C.

sclerite composed of 2 small elliptical pieces, not fused to occiput, very widely separated medially from each other. Antenna consisting of 3 segments and apical sensillum, slightly longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00 : 1.15–1.22 : 0.87–0.94. Labral fan with 32–36 main rays. Mandible (Fig. 4C) with mandibular serrations consisting of 2 teeth (1 large and 1 small); large tooth making nearly a right angle with mandible on apical side; supernumerary serrations absent (though 1 minute supernumerary tooth present between 2 mandibular serrations on the left mandible of 1 larva); comb-teeth composed of 3 teeth, shortened from 1st to 3rd. Hypostomium (Fig. 4D) with 9 apical teeth in row (though 4 intermediate teeth present between right corner and median teeth totalling 10 apical teeth in 1 larva); median and corner teeth well developed; median tooth of 3 intermediate teeth on each side smallest; lateral serrations weakly or moderately developed apically; 7–10 hypostomal bristles lying slightly divergent posteriorly from lateral margin on each side. Postgenal cleft (Fig. 4B) small, 0.29–0.50 times as long as postgenal bridge, with anterior margin

usually rounded or straight. Thoracic cuticle bare. Abdominal cuticle bare except both sides of anal sclerite moderately covered with simple colorless setae. Rectal scales present. Rectal organ (Fig. 4E,F) compound, each of 3 lobes with 0–6 short thumb-like or nodule-like secondary lobules. Anal sclerite of usual X-form, with anterior arms as long as, or slightly longer or shorter than, posterior ones; sensilla absent on and just posterior to basal juncture area; accessory sclerite absent. Last abdominal segment much expanded ventrally forming large ventral papilla. Posterior circlet with 88–90 rows of up to 16 or 17 hooklets per row.

TYPE SPECIMENS. Holotype female (with associated pupal exuvia) reared from pupa, collected from upper part of Mihara River, Hachijyo-jima Island, Izu Islands, Tokyo, Japan, 14.V.2005, by K. Saito. Paratypes: 1 female (reared from pupa), 4 males (reared from pupae), 1 pupa and 9 mature larvae, same data as those of holotype; 4 pupae, 1 pupal exuvia and 2 mature larvae, same data as those of holo-

type except date, 9.VII.2004; 2 pupae, 2 pupal exuviae and 3 mature larvae, Shu-sensui, Ni-jima village, Ni-jima Island, Izu Islands, 15.VI.2004, by K. Saito; 13 pupae, 3 pupal exuviae and 18 mature larvae, Takou-wan, Kouzu-jima Island, Izu Islands, 16.VI.2004, by K. Saito.

BIOLOGICAL NOTES. The pupae and larvae of this new species were found on the surface of leaves and stalks of trailing grasses in slow-flowing streams in all three islands. For example, in a type locality of Hachijyo-jima Island, the breeding stream, the upper part of Mihara River, was as follows: width ca. 1 m, depth ca. 5 cm, shaded, water temperature 25.0°C, altitude ca. 100 m above sea level, in an abandoned rice field. No other species was collected together with this new species.

DISTRIBUTION. Japan.

ETYMOLOGY. The species *izuense* refers to the name of the Islands, Izu, where this new species was found.

REMARKS. *Simulium* (*Nevermannia*) *izuense* sp. nov. is readily assigned to the *feuerborni* species-group redefined by Takaoka (2003) by the combination of the following characters: male genitalia with a simple lamellate ventral plate (Fig. 2C), a short inwardly-twisted style (Fig. 2C,E), several parameral hooks (Fig. 2J), and a simple narrow median sclerite (Fig. 2I); pupal gill with six long thread-like filaments per side (Fig. 3A); and larval head with small short postgenal cleft (Fig. 4B).

This new species seems to be most closely related to *S. (N.) sasai*, among the four Japanese species of the *feuerborni* species-group in that both species share similar characters in many features including the genitalia of both sexes, the number of horizontal and vertical rows of large upper eye facets in the male, the arrangement of pupal gill filaments (except the length of the stalk of the ventral paired filaments),

and the pattern of colored markings on the larval abdomen. However, *S. (N.) izuense* is distinguished from the latter species by the following characters (those of *S. (N.) sasai* in parentheses): in the female, the scutum with three dark longitudinal vittae (without such vittae), and fore basitarsus 7.2 times as long as its greatest width (8.2 times); in the male, the fore basitarsus 7.6 times as long as its greatest width (9.5 times); in the pupa, the absence of the anterodorsal projection on the cocoon (Fig. 3E) (presence) and the short stalk of the lower paired filaments (Fig. 3B)(medium-long stalk); and in the larva, the rectal organ with 0–6 short thumb-like or nodule-like secondary lobules per each lobe (Fig. 4E, F) (5–10 long finger-like secondary lobules) (Sato et al., 2005).

All the other three related Japanese species, i.e., *S. (N.) mie*, *S. (N.) morisonoi*, and *S. (N.) saitoi*, differ from this new species in the female by the chocolate-brown or orange-yellow scutum, in the male by the paramere with 7 or 9 hooks, in the pupa by the medium-long or long stalk of the ventral pair of gill filaments; and in the larva by the colored band on the first thoracic segment as well as colored markings on the abdomen (*S. (N.) mie* and *S. (N.) morisonoi*) or the absence of such colored markings on both thorax and abdomen (*S. (N.) saitoi*) (Takaoka, 1973, 1976; Takaoka and Saito, 2000).

Simulium (*N.*) *izuense* is also distinguished from the five other species of the same species-group in countries other than Japan, all of which have the simple cocoon: *S. (N.) borneoense* Takaoka from Borneo has the pupal gill with four filaments (Takaoka, 2001); *S. (N.) chitoense* Takaoka from Taiwan has the pupal gill with a medium-long stalk of the ventral pair of filaments (Takaoka, 1979); *S. (N.) chairuddini* Takaoka and *S. (N.) minahasaense* Takaoka, both from Sulawesi, and *S. (N.) perlucidulum* Takaoka from Luzon Island, have the common basal stalk of the pupal gill with a large transparent bulb-like organ ventrally (Takaoka, 1983,

2003).

The four known species of the *feuerborni* species-group were described from adult males (and also females in one species) alone, and then, their pupal and larval stages have remained unknown. Among these, *S. (N.) fuscinervis* Edwards from Sabah has the paramere with 10 or 11 hooks (Edwards, 1933); *S. (N.) bryopodium* Delfinado from Palawan Island, Philippines, has the dark brown hind femur and ventral plate much depressed posteriorly (Delfinado, 1971); *S. (N.) senile* Brunetti from West Himalaya bears the style with no apical spine (Brunetti, 1911); *S. (N.) rufithorax* Brunetti, described from a male and four females collected from India, has a reddish-brown thorax according to the original description (Brunetti, 1911).

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